PARTNERING IN THE AUTOMOTIVE SUPPLY CHAIN TO DEVELOP CLOSED-LOOP RECYCLING OF POST CONSUMER PET FOR AUTOMOTIVE FOAMS
Resinate Materials Group

- **Incorporated 2011: Plymouth, MI**
- **Vision:** To be the leading innovator in Performance Driven Green Chemistry
  - Extending the life-cycle of finite resource
  - Advance the circular economy

- **Technical Expertise**
  - 8200 ft² Product and Applications Development Facilities
  - Over 200 combined years of specialty chemicals experience
  - More than 20 patent applications based on recycled content

- **Core Technology:** Molecular up-cycling of spent materials into polyester polyols

- **Manufacturing through tolling partners and licensees**
  - Reduce capital investment
  - Expertise
  - Accelerate scale-up
Innovate
Collaborate
Rethink the way we take-make-use plastics

Polyester	Polyol
Automotive	Waste
Recycled	PET
PET	Pellets
or	flakes
Circular
Economy

Auto Manufacturing

Flexible Foam

Recycled PET

Automotive Waste

Composites
Adhesives
Foams
Coatings
Plasticizers

Polyester Polyol

Tier One

Resinate
Evolution of Resinate-Tier One-Ford Partnership

- Ford commitment to Green Chemistry
- Resinate dialog with Ford
- RMG samples sent
- Ford Testing in Flexible Foam applications
- Introduction to Tier One
- Performance testing at Tier One

- June 2016
- Aug 2016
- Sep-Dec 2016
- Jan 2016
- Mar 2016
CLOSED-LOOP RECYCLING OF rPET

Scope/Technical Approach:
- Reducing foam costs and extending raw material supplies
- Create closed-loop model for discarded PET feedstock
- Good mechanical and thermal properties

Problem:
- Unfavorable wet heat aging properties
- Vulnerable to gradual hydrolysis

Objective:
- To determine the stability and viability of rPET polyols in production of PU flexible foams for automotive applications. Physical, mechanical, and thermal properties were measured and compared to control samples purely composed of petroleum-based polyol.
# MATERIALS AND FORMULATION

- Description of recycled polyols, including appearance and recycled content

<table>
<thead>
<tr>
<th>Polyol Name</th>
<th>FFP1000-1.2</th>
<th>FFP1000-2.1</th>
<th>FFP1000-2.2</th>
<th>FFP1000-2.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Sustainable Content</td>
<td>95.5%</td>
<td>79.2%</td>
<td>82.1%</td>
<td>81.0%</td>
</tr>
<tr>
<td>% Recycled Content</td>
<td>12.7%</td>
<td>29.3%</td>
<td>32.2%</td>
<td>24.0%</td>
</tr>
</tbody>
</table>

- Formulas used to create individual foams; each component listed in a relative manner, by part

<table>
<thead>
<tr>
<th>Component</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyether Polyol</td>
<td>100.0</td>
<td>90.0</td>
<td>80.0</td>
<td>70.0</td>
<td>50.0</td>
</tr>
<tr>
<td>FFP1000-1.2/FFP1000-2.1/FFP1000-2.2/ FFP1000-2.3</td>
<td>0.0</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Niax A1</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Tegostab B4690</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Niax A300</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Lumulse POE (26) GLYC</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Diethanolamine</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Deionized Water</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Isocyanate</td>
<td>53.8</td>
<td>56.0/53.9/</td>
<td>58.4/54.3/</td>
<td>60.8/54.7/</td>
<td>65.7/54.3/</td>
</tr>
</tbody>
</table>
FOGGING AND ODOR

- Fogging:
  - SAE J1756, 3 h at 100 °C, 21 °C cooling plate, post-test cond. 16 h
  - Fog Number 70 min
  - Formation of clear film, droplets or crystals is cause for rejection

- Odor
  - Rating 3 max
  - FLTM BO 131-03-Variant C

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>FFP1000-1.2</th>
<th>FFP1000-2.1</th>
<th>FFP1000-2.2</th>
<th>FFP1000-2.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog Number</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>99*</td>
</tr>
<tr>
<td>Odor (23 °C)</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Odor (40 °C)</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Odor (65 °C)</td>
<td>2.0</td>
<td>2.0</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*oily spots present
CONCLUSIONS

- ‘Up-cycling’ a waste stream to create a sustainable, value-added polyol
- High rPET content foams are mechanically stronger & stiffer, and more thermally durable
- Positive photometric fogging results
- Odor and flammability test results meet Ford requirements.
- PET required for polyol synthesis and automotive foam production can come directly from automotive PET scrap
ONGOING PROJECTS

- Collaboration with Tier 1 and PDC (Headliner Team, WSS-M15P27-G).

- VOC
  - Micro-chamber and GC-MS

- Hydrolytic Stability
  - 60 °C and 98% Humidity for a duration of 3 weeks
  - Investigation of different glycol systems

- Manuscript submitted to WM journal.